

INTERFACES AT STERLING DEVELOPMENT LABORATORIES

Part A: The Ajax Recorder Gives Trouble

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Part A: The Ajax Recorder Gives Trouble

"We've noticed that our tape recorder isn't recording all the information we put into it," a programmer reported to Mr. John Street. Mr. Street was a program manager at Sterling Development Laboratories (S. D. L.) in Palo Alto, California. He was responsible for a large project in which the Ajax Company's digital tape recorder was an important component part. S. D. L. had had the recorder for three months but the system in which it was used had just been completed and this was its trial use. Mr. Street had been particularly anxious about whether the \$20,000 recorder would function properly because the Ajax Company had declared bankruptcy soon after shipping the recorder to S. D. L.

Some time before, when the recorder arrived at S. D. L., chief engineer Jackson and the programmer had thought that it worked satisfactorily but that its performance was far from flawless. Ajax had given S. D. L. no engineering help in setting up the recorder's performance. Ajax also failed to send the "documentation" it was to provide by the terms of its contract with S. D. L. The "documentation" was to include a list of spare parts, a circuit diagram, a description

of the recorder's operation, a maintenance manual, and a guide to adjustments. S. D. L. did receive the schematic diagrams. The recorder had several sensitive adjustments which had perhaps changed during shipping or might never have been made by Ajax. For example, the end-of-file function response was not always positive and longitudinal parity error occurred frequently. The lack of an adjustment manual was an inconvenience to S. D. L. from the beginning.

During the three months which followed the arrival of the recorder, Mr. Street had received a number of indications that S. D. L. might have trouble with it. First of all, Ajax had not sent documentation. Secondly, despite the fact that it had a model number, the recorder was not an "off-the-shelf" model as represented by Ajax. Ajax had previously manufactured several digital tape recorders using standard discrete circuit components, but the unit it delivered to S. D. L. was the first integrated circuit version of this model it had manufactured. Ajax had not told Mr. Street that the recorder his group would receive would be different from the Ajax standard model.

The project which Mr. Street was managing also involved a computer manufactured by Compco. Compco had done previous business with both S. D. L. and Ajax. Engineers at Compco told Mr. Street that Ajax had had some design problems

with the original recorder, but that these difficulties had been resolved. Compco had not heard of Ajax's switch to integrated circuits either. When Mr. Street contacted some of the engineers who had worked for Ajax before it went bankrupt, he discovered that much of the documentation for the new integrated circuit had never been written.

Mr. Street had to straighten out the recorder trouble as quickly as possible so that the production and assembly of other parts of the system would not be delayed. S. D. L.'s contract was a large one: to build a complete data collection system which included two antennas, two receivers, a transmitter, a data processing display, and recording center. The Ajax digital tape recorder was to record selected portions of the digital information developed in the data processor.

A computer, which the customer already owned, would control the entire system, including the tape recorder. The portion of the computer which operated the tape recorder was called the "magnetic tape controller." Controlling the recorder involved recognizing which information to record, starting and stopping the recorder at the appropriate times, and replaying the tape to retrieve the recorded information. The computer contained a buffer for the magnetic tape controller. The purpose of the buffer was to hold signals from the computer until the magnetic tape

controller could accept them and to route them to the right signal channel. This buffer address also reformatted the computer word to two 6-bit words which could be recorded by the recorder. The buffer also had to increase the voltage level of the signals before they entered the recorder. The buffer performed the reverse functions for playback.

S. D. L. was furnishing some display equipment to supplement the functions which the computer could perform. For example, the customer wanted to display certain data on screens. The customer's computer could not do this, so S. D. L. was designing equipment to make the displays possible. With the exception of the computer, S. D. L. was responsible for building all the components of the system.

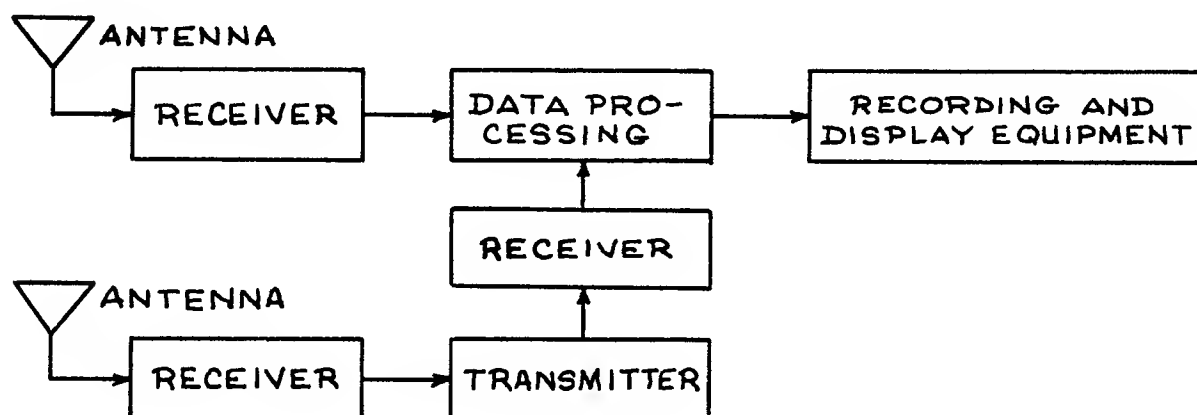


Figure 1. The Data Acquisition System

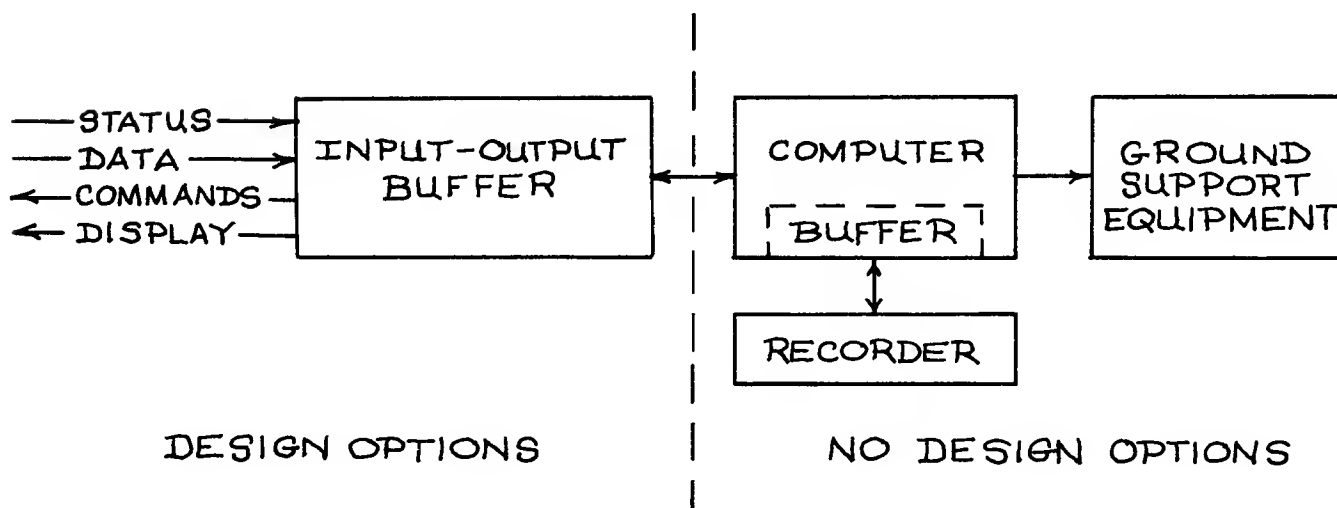


Figure 2
The Location of the Recorder in the System

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Part B: Correcting the Trouble

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Part B: Correcting the Trouble

When S. D. L. programmers noticed that the recorder was not recording all the information it was supposed to, no one knew precisely what was wrong. Any one of three sources could have been causing the difficulty. There might have been a physical malfunction such as a loose connection or a short circuit either in the magnetic tape controller or in the recorder itself. An error in the logic of the computer program could also have caused the trouble. This situation of having three possible error sources complicated the problem of determining why the recorder was failing to record information.

S. D. L. engineers spent some time examining the recorder and found some devious problems. In addition to being physically out of adjustment, the new integrated circuit recorder was not entirely compatible with the computer magnetic tape controller as Ajax had claimed it would be. For example, some of the control and timing signals were not functioning properly, which caused some data to be only partially transferred from computer to recorder, or in some cases, after being transferred, to

be immediately erased.

Because there was no engineering help available from the bankrupt Ajax Company, Mr. Street called on the Computer Group in Sterling Development Laboratories' Customer Engineering Service organization. This organization was not a part of S. D. L., but did belong to Actar Corporation, of which S. D. L. is one of several corporate divisions. The Computer Group was located across the street from S. D. L. Mr. Street could have called on a logic circuit expert within S. D. L. but he wanted someone who was accustomed to "trouble-shooting" digital equipment. The S. D. L. logic circuit people were primarily involved in design work. Engineer Rick Smith of the Customer Engineering Service organization had the requisite experience and was assigned to work on the S. D. L. problem. He began by examining the schematics in order to determine how the recorder worked. In view of their experience with Ajax, none of the S. D. L. project engineers was confident that the schematics were accurate, but Mr. Smith found that they were. Eventually, Mr. Smith found faults in the recorder which resulted from errors in design. He was able to correct these errors which seemed to have been the cause of the recorder's not taping all the

information. Mr. Street arranged for an engineer from Compco, the computer manufacturer, to assist because they had built computers which had interfaced with the earlier recorder model. The Compco engineer was able to help make the needed adjustments.

The engineers began trouble-shooting in January and had the recorder working properly by May. The solution to the recording problem did not have the highest priority. Effort was placed on it when no other use of the system was required and when personnel were available. In addition to Rick Smith, other men had spent considerable time trying to determine whether or not the computer program, the recorder, or the magnetic tape controller were causing recording problems. Mr. Street estimated that the problem took about 150 hours of Rick Smith's time, 100 hours of the Compco computer engineer's time, 60 hours of a programmer's time, 50 hours of engineering assistance, 80 hours of supervisory time, and 40 hours of the customer's time, in addition to approximately 100 hours lost because the trouble caused a delay in the development of the computer software. No delay was caused in the development of the overall system, however. An hour of an engineer's time costs S. D. L. about 20 dollars.

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Part C: How the Trouble Came About

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Part C: How the Trouble Came About

S. D. L. is only one part of a large corporation, Actar Corporation. There are several corporate divisions throughout the United States, and the corporate headquarters is in Philadelphia. Divisions include S. D. L., Space and Ballistic Systems, Aero-Electronics and Communications and Engineering. When a customer requests a bid from Actar, the bid is received in the Philadelphia offices and is sent from there to the appropriate division of Actar. Usually the customer has had previous contact with a manager in a specific group of a division, and the bid request comes as no surprise. If a contract is unusually large, such as 20 million dollars per year for several years, then a new organization may even be formed to accommodate the contract.

S. D. L. itself is divided into three organizations: the Communication Terminal Organization (CTO), Air Terminal Operations (ATO), and the Composite Instrumentation Organization (CIO). S. D. L. does much work with satellite ground communication and control systems. CIO is primarily concerned with the design and fabrication of display and

digital data handling and control equipment, such as computers, input/output buffers, consoles, etc., used on the ground as opposed to in a satellite. ATO is concerned with communications and control systems between ground installations and satellites for one specific contract. CTO is responsible for ground terminals as used for COMSAT or other communication satellites. These three operations are quite flexible and often, for the sake of efficiency or convenience, do work whose nature might better be described by the title of another division. Each of the operations also has certain tasks it performs for the benefit of all three organizations. For example, ATO does human factors work and performs reliability studies while CIO manages the documentation for all groups. Mr. Street says that this kind of flexibility is very important in S. D. L.'s organization.

Mr. Street had been working at S. D. L. for six years when he was promoted to Manager of the Special Programs Department, part of the Advanced Data Collection Activity in CTO. He had graduated from Washington State College in math after changing from electrical engineering. "I wanted to study something more than the operating principles of rotating machinery," he said. "Math somehow

seemed more appealing to me." A large part of his work experience prior to coming to S. D. L. was with the aerospace industry.

Mr. Street's predecessor had had a large number of discussions with the data system customer before receiving the request for quotation (RFQ) and also prior to being awarded the contract. Since S. D. L. was prepared in advance for the proposal, the Philadelphia headquarters sent the RFQ directly to the Advanced Data Collection Activity.

The customer placed some constraints on the way in which a contract would be implemented. For example, the customer already owned a Compco computer which he insisted be used in the system. The nature of the electronic interface between the digital recorder and the computer magnetic tape controller was sufficiently unique that only two recorder models were immediately available for consideration. The customer would not permit S. D. L. to buy any equipment which would require modification or new design.

Two companies, Ajax and Tape-Co, made recorders of a type which could be used with the customer's Compco computer. The Ajax recorder had already been used with the Compco computer. The Tape-Co and Ajax recorders were the same in price, but differed in that the Tape-Co recorder was used

in a configuration requiring two recorders while the Ajax system used only one recorder. Because of this difference, Compco had made two types of magnetic tape controllers: one to operate the Ajax single recorder system and another to operate the dual recorder system made by Tape-Co. Tape-Co was a well-known and reliable company; Ajax was not well-known. Compco had worked with both companies before. Interfaces between the Ajax recorder and the magnetic tape controller made by Compco had already been worked out; the interfaces between the Tape-Co dual recorder system and its controller were still in the process of being tested. The customer's need was for a single rather than a dual recorder system and the selection of a Tape-Co single recorder would require modification of the Compco dual recorder magnetic tape controller. Because the customer had restricted S. D. L. from buying equipment which would require costly modifications, Mr. Street investigated the possibility that the Tape-Co recorder might be compatible with the Compco single recorder tape controller. This became the crucial question which would determine the recorder Street would buy. When Street posed the question to Tape-Co, however, Tape-Co refused to promise that no modifications would be needed. Mr. Street informed the customer of the

situation but was advised that S. D. L. should buy no equipment which would need modification. Street then decided that S. D. L. had little choice but to select the Ajax recorder.

Mr. Street had the authority to make up to \$50,000 single purchases. Because S. D. L. does not like to buy from a "single source" supplier, Mr. Street informed the Purchasing Department of the technical and financial problems and recommended purchase of the Ajax recorder.

"If we had investigated the Ajax Company more carefully at that time, we might have discovered it was in financial difficulty," Mr. Street commented in retrospect. "Under the circumstances, we might have convinced the customer to be more flexible and avoided the whole mess. The experience has shown me that it is essential not to leave some important factor unexplored. In this case we all made the mistake of assuming Ajax was solvent only because it had delivered a unit to our customer of a type we could use. We transferred that one fact into complete acceptance of the company. And, of course, events proved that faulty judgment can be a serious mistake."